STANDARDS OF CONSTRUCTION ON SECONDARY AND RURAL HIGHWAYS

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When we speak of standards for anything we usually think of a rather definite level, quality, or character which is established as proper or adequate for the purpose we have in mind. This is customary in Highway Engineering, and as a result there are standards of construction for secondary and rural highways. While they may be somewhat definite they are not permanent, or at least they haven't been permanent throughout past years. Most of us can easily remember the time when standards for primary roads (such as they were) stood at about the level that we are now prescribing for secondary and rural roads. At that time the standards may have been proper—all things considered—but history showed that they weren't adequate.

That fact alone calls for some serious thought as to what is proper and what is adequate at this early stage in our rural program. It is one thing to get the people up out of the mud; it is another to keep them there. If the standards of design and construction are not high enough, the initial investment will soon be lost unless it is supplemented by costly maintenance year after year. That is the reason why some forethought must be given to the possibility of a road becoming inadequate for traffic requirements that may multiply because of its improvement; that is also the reason why the standards must be kept higher than sometimes seems necessary even though the road may never carry more than 25 cars per day.

The standards required for a lasting road in practically all instances cannot be economically justified if the traffic count never exceeds 25 cars per day. By economically justified, I mean that the revenue produced by the operation of vehicles on that road (or on any and all of the highways over which these cars pass) would never equal the cost of the road itself. Considered from this standpoint, each mile of the highway would account

for no more than 365x25 or about 9000 car miles per year. If the average gasoline mileage is as low as 14 per gallon, at a 7 cent tax per gallon the revenue produced directly by each mile year would be about 45 dollars. It is easy to visualize retirement of a construction "debt" sometime in the next century provided there is no maintenance required in the meantime.

Obviously rural and rural secondary highways cannot be considered from that standpoint alone. We prefer to judge them from the standpoint that our Commonwealth means what it says, we operate for the general welfare—what's good for one is good for all—and vice versa. Each citizen in the state is entitled to access to his church, his school, his markets, and the seat of his government, no matter how remote they may be. If that is the case, those who have ready and convenient access to these things must help bear the cost for those who find them more remote. Thus car users in the thickly populated areas must contribute to the building of roads in the sparsely populated sections of the state. Some of these are roads that the city dweller will never see, but you don't have to drive on a road to get value from it.

That is the principle which we have adopted, and there is some precedent which says it is a good one. Our State Highway System, as well as the whole system of Federal Aid, is based on this idea, and I shudder to think of the quality of primary roads over which you would drive in some of the "wide open spaces" on your way to California if it were not for the operation of this principle. But that is beside the point. We are committed to this idea, and being committed to it the immediate concern is how best to construct the roads so that they will be adequate and lasting. That is a matter for engineering judgment.

It is my purpose here today to discuss some of the things which enter into standards of construction, and to this I would like to add standards of design. One can be no better than the other insofar as the quality of the finished road is concerned. The very first thing that we think of is year-around passage, and surprisingly enough it isn't wholly dependent on what or how much material is put down as riding surface. Grading and drainage are fundamentally more important. The position of

the road bed with respect to surrounding land, and the possibility for natural surface drainage to go on uninterrupted by this roadbed are critical factors in the stability and load-carrying capacity of the road.

Ditches alongside the road help serve this purpose, as do cross pipes or culverts which carry accumulated water from one side of the road to the other where natural drainage ways exist. Provisions for this must be made on rural highways as carefully, although not as elaborately, as on primary roads. No road can exist without them, and when I say exist I mean exist. All of us have seen roads (more specifically trails), particularly in rather rugged country where the "road" has become the drainage way itself and washed out completely or at least has no chance of serving as an all-weather road.

Standard requirements for this grading operation must take into account several other things such as the sharpest curve that will be permitted and the maximum grade (or steepest hill, if you prefer) that will be allowed. Obviously those should vary with the character of the land, because standards that could be met with ease and little expense in flat or even rolling country would be absolutely prohibitive in mountainous regions. Regardless of topography, there is no reason for setting our standards as high as those that are now common for primary roads throughout the country. It is difficult to find reasons of safety or convenience that would not let grades go as steep as 8 per cent and curvatures run up to 10 degrees in flat country even if the traffic was as high as 400 vehicles per day. Every effort should be made to keep the maximum grade as low as possible (perhaps 10 and not more than 12 per cent) in mountainous regions when the traffic count is that high, but considerable sacrifice can be made in the degree of curvature without creating much more than an annoyance for the drivers.

With greatly reduced traffic counts, more liberties must be taken with the grade and alignment although in the flat regions there is still little possibility or justification for increased grades unless it be for the purpose of salvaging existing roads. If the traffic count is down to 100 or fewer cars per day, the grade in mountainous country could very well run up to 15 per cent which is admittedly steep but still in line with the light

use. Similarly, when the traffic is much below 100 cars per day degrees of curvature should be allowed to increase considerably in order to maintain the grade and make the road conform as much as possible to land features without going into excessive grading operations. Probably it would be desirable to let curvatures run up past 50 degrees (which is getting into "hair pins") in mountainous regions but they should be kept far below that in sections with flat topography.

Another consideration is the width of the roadbed and the width to which surfacing material will be placed on that roadbed. Here again, the anticipated traffic logically has much influence. The topography of the land often has a lot to do with widths that have been used, however these should be considered not as matters of "Standards" but rather as matters of expediency. While there are reasons of safety and convenience which would suggest greater widths in more rugged country, there are always reasons of practicality and economy to counterbalance them. On the whole a good rule to follow is "let the traffic determine the width", so long as other factors such as cost do not make this impractical.

Although it may seem obsolete to some of us, there is still a logical place for the one-lane road in our rural highway system. The simple economics which were outlined earlier are the basis for justification. In order to get an all-weather road at all, those who live on or operate over roads that carry fewer than 25 cars a day will see the necessity for this standard which seemingly is obsolete. It is a case of a narrow road or no road. Even so, we can improve over old practices by never having less than a 12-foot roadbed carrying a surface that is 9 feet wide. This arrangement supplemented by turnouts for passing that are at least 12 feet wide and are spaced within sight distance of each other, should be more than adequate for the traffic demands.

If the anticipated traffic is much above 25 per day, and there are no restrictive influences such as topography and excessive cost, then it is best to go on up to at least 16 or 18-foot surface on a roadbed that is at least 20 to 24 feet wide. There is a reason for jumping over intermediate widths even though there may be intermediate traffic demands. We have to decide

whether conditions justify a one-lane or a two-lane road. If they require a two-lane road, then it is only reasonable to provide one that can carry traffic in two directions with reasonable safety and at reasonable speeds in order to avoid congestion. Anything short of this may be a half-way measure.

Matters of right-of-way widths are influenced by several factors such as depth or height or cut or fill in conjunction with road widths and other things which have already been set. As a general proposition, the right-of-way should be a minimum of 40 feet in width and that should be increased to as much as 60 feet if the traffic values require other standards of grade, alignment, and roadbed width that are commensurate with more right-of-way. There appears to be little reason for going beyond 60 feet, because if future conditions might develop traffic of much greater magnitude, then the road would be raised out of the rural and secondary class anyway and the expense of great alterations including more rights-of-way would be justified.

Unless there is reason to do otherwise, cut and fill slopes should not be steeper than the old time-tried and well-proven 1½ on 1, except in solid rock where the slopes can be practically vertical. Some of us know of sections of the state or situations where it would be economical to do otherwise, but those are special conditions which require special designs outside standards. Certainly we should not adhere to hand finishing of slopes as is done in the construction of our higher types of roads. Any problems that will develop with cutting and filling—and we all know there will be some—are not the type that can be solved by hand finishing. For that matter, considerable sacrifice on the tolerance in grade would not be out of line either (perhaps as much as 0.5 foot), so long as there is no tendency developed to be more lenient on the job than specifications permit. The greatest effort should be made toward elimination of sharp breaks or "bumps" in the grade caused by lack of uniformity in finishing. This should make for reductions in cost that are far out of proportion to the tolerances given, because with modern machinery it is not nearly as difficult to obtain smoothness of grade as it is to get exactness in elevation.

With all of these things determined, we now come to the factor which ultimately gets us up out of the mud—the surface.

All roads must be surfaced, and probably in the initial stages practically all roads could have the lowest type of surface which is known in the highway industry as traffic bound material. This consists of gravel, stone, slag, or even mine refuse, placed on the roadbed uniformly and allowed to compact or become "bound" together by the action of traffic. Although it is recognized generally but often overlooked specifically, the binding power and lasting qualities of the aggregate or road metal (as these materials are called) are dependent on the composition and gradation of these materials.

It is possible and even probable that most specifications do not provide materials suitable for traffic bound construction. In the first place, a good durability requirement for aggregate going into high-type construction is not necessarily a good durability requirement for traffic-bound aggregate. Secondly, an aggregate may be durable and still have poor binding qualities. It is necessary for us to differentiate between these, use our best judgment in the absence of more definite guides, and sometimes select materials for advantages that have not been recognized before.

Certainly there is no reason to transport materials great distances to jobs in areas having abundant local materials. It may be that these local materials are unsatisfactory, but every effort should be made to prove beyond doubt that they will not meet requirements. On that score, it may be desirable to change standard specification requirements enough to make use of materials that have good possibility of serving the purpose yet excluding those that are definitely of inferior quality. Also, there is often a tendency toward coarseness in traffic bound materials which could be counteracted by a mixture of many sizes including a fairly large amount of fines.

With regard to the amount or thickness of surfacing, there is no condition where less than 3 inches of material would be adequate, and hardly anywhere more than 6 inches of material would be proper for the initial treatment. If circumstances (including weights as well as volumes of traffic) indicate that more support is necessary, then a higher type of construction with a well designed base course or stabilized subgrade overlaid by a light surface is in order. Regardless of the amount

of traffic, the traffic bound surface is going to need some upkeep, and if the traffic is high enough a step-up to a higher type surface is desirable as soon as possible to avoid constant and costly maintenance. But that is another matter as is that of drainage facilities which are of utmost importance. Both of these are covered in the paper which follows.

There are no hard and fast rules that can be followed in setting up standards for the construction of highways of any class. Nevertheless, there are obviously reasons why standards must be adopted, and there are reasons of logic and experience that can be followed in arriving at our standards. These must be engineering logic and engineering experience, and if past performance is any indicator of what we can expect in the future, we should have no fear that engineers charged with rural and secondary highway construction will provide standards that are too high or too low for our own good.